



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.03.2013 Bulletin 2013/11

(51) Int Cl.:
F02N 11/08 (2006.01) **F02D 29/02** (2006.01)
F02N 15/00 (2006.01)

(21) Application number: **11777455.4**

(86) International application number:
PCT/JP2011/060504

(22) Date of filing: **02.05.2011**

(87) International publication number:
WO 2011/138936 (10.11.2011 Gazette 2011/45)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **07.05.2010 JP 2010106861**

(71) Applicant: **Hitachi Automotive Systems, Ltd.**
Hitachinaka-shi
Ibaraki 312-8503 (JP)

(72) Inventors:
• **OMATA Shigehiko**
Hitachinaka-shi
Ibaraki 312-8503 (JP)
• **NAGASAWA Yoshiaki**
Hitachinaka-shi
Ibaraki 312-0062 (JP)

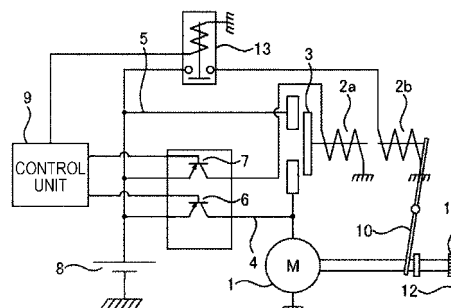
• **KOKUBUN Shuuichi**
Hitachinaka-shi
Ibaraki 312-8503 (JP)
• **YABUKI Minoru**
Hitachinaka-shi
Ibaraki 312-0062 (JP)
• **NAKAZATO Shigenori**
Hitachinaka-shi
Ibaraki 312-0062 (JP)
• **YANAGAWA Norio**
Hitachinaka-shi
Ibaraki 312-0062 (JP)
• **KITAJIMA Shingo**
Hitachinaka-shi
Ibaraki 312-8503 (JP)

(74) Representative: **MERH-IP**
Matias Erny Reichl Hoffmann
Paul-Heyse-Strasse 29
80336 München (DE)

(54) **ENGINE STARTER AND METHOD FOR CONTROLLING ENGINE STARTER**

(57) When an engine is started, a relay (13) is driven from the control unit (9) and a second solenoid (2b) is driven. Then, a Duty signal by PWM is transmitted to a first semiconductor switch element (6), and a current flows from a battery (8) to a starting motor (1) in a first current circuit via wiring (4) and the first semiconductor switch element (6) to the starting motor (1). By the Duty signal, the current is restricted only in a predetermined time, then, the control unit (9) drives the relay (13), and thereby, drives a first solenoid (2a), an auxiliary current circuit adapted to be in parallel to the first current circuit is closed, and currents are supplied to the starting motor (1) in the first current circuit and the auxiliary current circuit connected in parallel.

[FIG. 1]



Description

Technical Field

[0001] This invention relates to a system of starting an engine using a starting motor and a control method thereof.

Background Art

[0002] For environmental measures and saving energy sources, it has been considered to automatically stop idling by shutting off a fuel supplied to an engine when a predetermined condition permitting temporary stop of the engine during driving of an automobile is fulfilled, and it has been implemented in some automobiles.

[0003] In the automobile having the function of idling stop, it is necessary to drive an engine starting system at each time of restart after idling stop. The current consumed by the engine starting system is compensated for by charging using a power generator during driving of the automobile engine, and therefore, to reduce the current consumed by the engine starting system may be one of measures for improvement of fuel efficiency.

[0004] Further, at each time of restart after idling stop, electrical equipment such as a navigation system may be momentarily stopped because of voltage drop of a battery due to the initial excessive current flowing in the starting motor, and reduction of the current consumption of the engine starting system is demanded.

[0005] As a technology of fulfilling the demand, control of the excessive current after a starting switch is turned on has been performed using a semiconductor switch element and a control unit thereof as disclosed in Patent Document 1.

Prior Art Documents

Patent Documents

[0006]

Patent Document 1: Japanese Patent No. 2616510

Patent Document 2: Japanese Patent No. 4214401

Summary of Invention

Technical Problem

[0007] When a starting motor of turning on an energization path to a motor with a semiconductor switch element is used for idling stop, three types of engine restart modes are conceivable. The first mode is engine restart when starting moving on a green light after stopping on a red light for one minute, for example.

[0008] The second mode is restart when a restart request of the engine is issued in an automatic stop period of the engine after an automatic stop request is issued

during driving of the engine as disclosed in Patent Document 2.

[0009] The third mode is restart when a restart request is issued immediately after the automatic stop of the engine is completed and the engine is completely stopped.

[0010] In the prior art technology of Patent Document 1, there is no problem in the first restart mode, however, in the second restart mode, there is a problem that, when a restart request is issued at swing-back (negative rotation) immediately before the engine rotation is completely stopped, the current load on the starting motor becomes excessive and the temperature of the semiconductor switch element as a part of a current circuit to the starting motor rises beyond the acceptable range. Further, in the third restart mode, there is a problem that, when the engine restart request is issued immediately after the engine is completely stopped, the pressure within the cylinders of the engine remains high in the case where the pistons of the engine are stopped before the top dead center or the like, the current load on the starting motor becomes excessive and the temperature of the semiconductor switch element as the part of the current circuit to the starting motor rises beyond the acceptable range.

[0011] Further, for self-propulsion of a vehicle using power of the starting motor in a manual transmission car, in the related art technology of Patent Document 1, there is a problem that the temperature of the semiconductor switch element rises beyond the acceptable range.

[0012] Furthermore, when a predetermined time is taken until a control unit for controlling the semiconductor switch element becomes operative (for example, start by Key), there is a problem that the start of the engine should be awaited until the control unit becomes operative.

[0013] In addition, in the case where the engine is started when the engine is cold (including the extremely low temperature such as -25°C), there is a problem that the current load on the starting motor becomes larger because of reduced viscosity of the engine oil or the like, and the gasoline is hard to be gasified and the start of the engines takes time due to the low temperature, and the temperature of the semiconductor switch element rises beyond the acceptable range.

[0014] However, those problems have not sufficiently been considered in the related art technologies.

[0015] An object of the invention is to provide an engine starting system using a semiconductor switch element that can improve reliability of the semiconductor switch element even when an excessive current flows in a motor.

Solution to Problems

[0016] The object has been achieved according to the invention described in claims.

[0017] For example, according to one embodiment of the invention, an engine starting system includes a semiconductor switch element and a starting motor, and starts an engine of a vehicle by drive power of the starting motor by turning on a current circuit to the starting motor

according to an instruction signal using the semiconductor switch element, and the system includes a restriction unit that restricts energization to the starting motor by controlling the semiconductor switch element using a Duty signal by PWM or a Duty signal with an unfixed frequency, and, with the current circuit via the semiconductor switch element as a first current circuit to the starting motor, an auxiliary current circuit to the starting motor adapted to be in parallel to the first current circuit and to open and close independently of the first current circuit. Advantage of the Invention

[0018] According to the invention, in a starting motor system, using a semiconductor switch element, an engine starting system that can improve reliability of the semiconductor switch element even when an excessive current flows in a motor may be provided.

The other purposes, features, and advantages of the invention will be clear from the following description of the embodiment of the invention with respect to the accompanying drawings.

Brief Description of Drawings

[0019]

[Fig. 1] Fig. 1 is a configuration diagram showing one embodiment of an engine starting system of the invention.

[Fig. 2] Fig. 2 shows current waveforms of a starting motor at the first restart of an engine.

[Fig. 3] Fig. 3 shows current waveforms of the starting motor at the second restart of the engine.

[Fig. 4] Fig. 4 shows current waveforms of the starting motor at the third restart of the engine.

Description of Embodiment

[0020] As below, one embodiment will be explained in detail with reference to the drawings.

[0021] Fig. 1 is an explanatory diagram showing an example of an engine starting system according to the invention. A starting motor 1 for starting an engine (not shown) is connected to a battery 8 by a first current circuit via a harness (wiring) 4 and a first semiconductor switch element 6. Further, the starting motor 1 is also connected to the battery 8 by an auxiliary current circuit via an electromechanical switch 3 of a first solenoid 2a and a harness 5 adapted to be in parallel to the first current circuit, and the other end of the battery 8 is grounded.

[0022] Note that the auxiliary current circuit may be adapted to be opened and closed not by the electromechanical switch 3, but by a semiconductor switch element (not shown).

[0023] Further, one end of the first solenoid 2a is connected to the battery 8 via a second semiconductor switch element 7 and the other end is grounded. For the energization to the first solenoid 2a, the second semiconductor switch element 7 may not be used, but connection to

the battery 8 via a vehicle relay (not shown) in general use may be used. A second solenoid 2b is connected to the battery 8 via a relay 13 driven by a control unit 9, but may be connected to the battery 8 via a semiconductor switch element (not shown).

[0024] To the first semiconductor switch element 6 and the second semiconductor switch element 7, control signals of Duty signals by PWM (Pulse Width Modulation) or Duty signals with unfixed frequencies may be supplied from the control unit 9.

[0025] In the case where a predetermined condition is fulfilled and idling of the engine is stopped, and then, a restart request of the engine (for example, release of the brake pedal) is issued by a driver, Duty signals by PWM are supplied from the control unit 9 to the first semiconductor switch element 6 and the second semiconductor switch element 7, and the relay 13 is driven. Alternatively, the frequencies of the Duty signals may not be fixed.

[0026] A shift lever 10 transmits an amount of movement of the second solenoid 2b to a pinion 11, the pinion 11 meshes with a ring gear 12 coupled to the rotation shaft of the engine and the rotation force of the starting motor 1 is transmitted to the ring gear 12, and thereby, the engine is cranked and started.

[0027] Of the above described three types of engine restart modes in the configuration, first, the first restart mode (engine restart when starting moving on a green light after stopping on a red light for one minute) will be explained using Fig. 2. When the vehicle speed and the driving situation are checked and the condition for idling stop of the engine is satisfied, the engine is stopped by cutting the fuel or otherwise as shown by (1) in Fig. 2. In the stopping process of the engine, a predetermined condition, for example, the number of rotations of the engine is achieved to 400 rpm, the Duty signal by PWM is transmitted in a short time from the control unit 9 to the first semiconductor switch element 6, and the starting motor 1 is rotated. The number of rotations of the starting motor 1 and the number of rotations of the engine are monitored, the control unit 9 drives the relay 13 and the solenoid 2b is driven at the time when both numbers of rotations may be nearly synchronized, and thereby, the pinion 11 meshes in the ring gear 12 of the engine by the shift lever 10 and waits for a restart request of the engine. (3), (3a), (3b) of Fig. 2 show the currents flowing in the starting motor 1 when the Duty signal by PWM is transmitted in a short time from the control unit 9 to the first semiconductor switch element 6 and the starting motor 1 is rotated. (3) shows the case where energization is performed only by a mechanical contact like the starting motor well known in related art, and, by controlling the energization of the first semiconductor switch element 6, the energization is controlled to the minimum necessary current value as shown in (3b), and the voltage drop (not shown) of the battery may be kept to the minimum necessary.

[0028] Then, when the restart request is issued after the signal turns green, for example, the relay 13 is driven

from the control unit 9 and the second solenoid 2b is driven, and the state in which the pinion 11 that has already meshed with the ring gear 12 is meshing with the ring gear 12 side is held via the shift lever 10 and the Duty signal by PWM is transmitted to the first semiconductor switch element 6. By the transmission of the Duty signal, a current flows from the battery 8 to the starting motor 1 via the harness 4 and the first semiconductor switch element 6 and the starting motor 1 rotates, the ring gear 12 of the engine rotates via the pinion 11, and thereby, the engine is restarted. (5), (5)a, (5)b of Fig. 2 show the currents flowing in the starting motor 1 in this regard. Like (3), (3)a, (3)b, compared to the current (5) when the energization is performed only by the mechanical switch of the starting motor well known in related art, the energization is performed in the minimum necessary current value by energization control using the first semiconductor switch element 6, and thus, the voltage drop (not shown) of the battery may be kept to the minimum necessary.

[0029] As described above, the energization path to the starting motor 1 in the first restart mode is only the first current circuit from the battery 8 via the first semiconductor switch element 6 and the harness 4.

[0030] Next, the second restart mode will be explained as below.

[0031] (6) of Fig. 3 shows when a restart request of the engine is issued in the automatic stop period in which the condition of idling stop is satisfied and the engine is automatically stopped. When the restart request is made nearly at the swing-back (negative rotation) immediately before the engine rotation is completely stopped, the current load on the starting motor 1 becomes excessive. As an example, compared to the energization current (5)b to the starting motor 1 in the first restart mode, in the restart in the middle of the engine rotation stop, the load current to the starting motor 1 becomes excessive as shown by (7).

[0032] When the restart request is issued, the relay 13 is driven from the control unit 9 and the second solenoid 2b is driven, the state in which the pinion 11 that has already meshed with the ring gear 12 is meshing with the ring gear 12 side is held via the shift lever 10, then, the Duty signal by PWM is transmitted to the first semiconductor switch element 6, and a current flows from the battery 8 to the starting motor 1 via the harness 4 and the first semiconductor switch element 6. By the Duty signal by PWM, the current is restricted only in a predetermined time, then, the control unit 9 drives the relay 13, and thereby, drives the first solenoid 2a, the auxiliary current circuit (the battery 8 to the harness 5 to the electromechanical switch 3) adapted to be in parallel to the first current circuit is closed, and currents are supplied in the first current circuit and the auxiliary current circuit connected in parallel in the starting motor 1. Then, when the swing-back is ended, the engine rotates in the positive rotation direction, and the pistons exceed the top dead center or after the pistons exceed the top dead center,

the control unit 9 terminates the driving of the relay 13 so that the auxiliary current circuit may be closed. Alternatively, the auxiliary current circuit may remain connected to the first current circuit in parallel after the engine is started before the starting motor is stopped. (8), (8) a, (8)b of Fig. 3 show the currents flowing in the starting motor 1 at the restart. Compared to the current (7) when energization is performed using only the first current circuit, by providing the first current circuit and the auxiliary current circuit in parallel, the current (8)a of the first current circuit via the first semiconductor switch element 6 becomes significantly smaller than the total current (8) of the first current circuit and the auxiliary current circuit.

[0033] Next, the third restart mode will be explained as below.

[0034] (9) of Fig. 4 shows when a restart request is issued immediately after the automatic stop of the engine is completed and the engine is completely stopped, and the pressure within the cylinders of the engine remains high in the case where the pistons (not shown) of the engine are stopped before the top dead center or the like and the current load on the starting motor becomes excessive. Compared to the energization current (5)b to the starting motor 1 in the first restart mode, in the restart immediately after the engine rotation stop, the current load on the starting motor 1 becomes excessive as shown by (10).

[0035] When the restart request is issued, the relay 13 is driven from the control unit 9 and the second solenoid 2b is driven, the state in which the pinion 11 that has already meshed with the ring gear 12 is meshing with the ring gear 12 side is held via the shift lever 10, then, the Duty signal by PWM is transmitted to the first semiconductor switch element 6, and a current flows from the battery 8 to the starting motor 1 via the harness 4 and the first semiconductor switch element 6. By the Duty signal by PWM, the current is restricted only in a predetermined time, then, the control unit 9 drives the relay 13, and thereby, drives the first solenoid 2a, the auxiliary current circuit (the battery 8 to the harness 5 to the electromechanical switch 3) adapted to be in parallel to the first current circuit is closed, and currents are supplied in the first current circuit and the auxiliary current circuit connected in parallel in the starting motor 1. Then, the movement of the pistons of the engine is checked by the signal of a crank angle sensor (not shown) or the like, when the pistons exceed the top dead center or after the pistons exceed the top dead center, the control unit 9 terminates the driving of the relay 13 so that the auxiliary current circuit may be closed. Alternatively, the auxiliary current circuit may remain connected to the first current circuit in parallel after the engine is started before the starting motor is stopped. (11), (11) a, (11) b of Fig. 4 show the currents flowing in the starting motor 1 in this regard. Compared to the current (10) when energization is performed using only the first current circuit, by providing the first current circuit and the auxiliary current circuit in parallel, the current (11)a of the first current cir-

cuit via the first semiconductor switch element 6 becomes significantly smaller than the total current (11) of the first current circuit and the auxiliary current circuit.

[0036] Therefore, in the second and third restart modes in which the excessive currents flow in the starting motor 1, by connecting the first current circuit and the auxiliary current circuit in parallel, the energization current to the first semiconductor switch element 6 can be significantly reduced and the current capacity of the first semiconductor switch element 6 may be made the necessary minimum, and additionally, the starting system with high reliability can be supplied.

[0037] However, if the first, second, third restart modes are determined and controlled, the configuration becomes complex, and, when the engine is restarted after idling stop, the first current circuit and the auxiliary current circuit may be constantly controlled to be in parallel and the current in the first current circuit via the first semiconductor switch element 6 may be reduced in any one of the restart modes.

[0038] Further, in the manual transmission car, even when self-propulsion of the vehicle using power of the starting motor is necessary, the current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM and using the auxiliary current circuit as the main current path to the starting motor, and thereby, the engine can be started without losing the reliability of the first semiconductor switch element.

[0039] Furthermore, in the first current circuit to the starting motor 1 via the first semiconductor switch element 6, even when the temperature of the first semiconductor switch element 6 rises beyond the acceptable range or becomes dysfunctional, the energization to the starting motor may be performed by closing only the second current path and the engine can be started.

[0040] In addition, even when a predetermined time is taken until the control unit for controlling the first semiconductor switch element 6 and the second semiconductor switch element 7 becomes operative (for example, start by Key), the first solenoid 2a adapted to be driven via a vehicle relay (not shown) in general use is driven, and thereby, the current can be supplied to the starting motor 1 via the auxiliary current circuit and the engine can be quickly started without waiting in the predetermined time.

[0041] Further, in the case where the engine is started when the engine is cold (including the extremely low temperature such as -25°C), the current load on the starting motor 1 becomes larger because of reduced viscosity of the engine oil or the like, and the gasoline is hard to be gasified and the start of the engine takes time, the temperature of the first semiconductor switch element 6 rises beyond the acceptable range in the first current circuit. However, the current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM and using the auxiliary current circuit as the main current path to the starting

motor, and thereby, the engine can be started without losing the reliability of the first semiconductor switch element.

[0042] Furthermore, to improve the life of the first semiconductor switch element 6, means for opening and closing the auxiliary current circuit is formed using a semiconductor switch element and the function of the first current circuit and the function of the auxiliary current circuit are controlled by the control unit 9 to be alternate or at nearly equal use frequencies, and thereby, the use limit (life) of the first semiconductor switch element can be extended to nearly twice.

[0043] In addition, for protection of the first semiconductor switch element 6, in the first current circuit to the starting motor 1 via the first semiconductor switch element 6, the temperature of the first semiconductor switch element 6 is monitored, given that the temperature of the first semiconductor switch element 6 is the acceptable value, for example, 170°C, when the temperature becomes the threshold value 150°C below the value, the control signal to the first semiconductor switch element 6 is stopped to open the first current circuit and close only the second current path in the control unit 9, and thereby, energization to the starting motor is performed. In this manner, the engine may be started without losing the reliability of the first semiconductor switch element 6. Further, for protection of the first semiconductor switch element 6, in place of the above described method of monitoring the temperature of the semiconductor switch element, by checking the current and the energization time of the first semiconductor switch element 6, when current x energization time exceeds a predetermined value, the control signal to the first semiconductor switch element 6 is stopped to open the first current circuit and close only the second current path in the control unit 9, and thereby, energization to the starting motor is performed. Also, in this manner, the engine can be started while the first semiconductor switch element is protected. Furthermore, the protection of the semiconductor switch element may be realized by a method using both the temperature and the current x energization time of the semiconductor switch element. Note that the predetermined value also varies depending on the relationship between heat generation and discharge of the element. The above description has been made with respect to the embodiment, however, as will be understood by the person skilled in the art, the invention is not limited to that and various changes and alterations may be made within the spirit and the appended claims of the invention.

Reference Signs List

[0044]

- | | |
|----|--------------------------|
| 1 | starting motor |
| 2a | first solenoid |
| 2b | second solenoid |
| 3 | electromechanical switch |

- 4 harness of first current circuit
- 5 harness of auxiliary current circuit
- 6 first semiconductor switch element
- 7 second semiconductor switch element
- 8 battery
- 9 control unit
- 10 shift lever
- 11 pinion
- 12 ring gear of engine
- 13 relay

Claims

1. An engine starting system including a semiconductor switch element and a starting motor, and starting an engine of a vehicle by drive power of the starting motor by turning on a current circuit to the starting motor according to an instruction signal using the semiconductor switch element, the system comprising:

restricting means for restricting energization to the starting motor by controlling the semiconductor switch element using a Duty signal by PWM or a Duty signal with an unfixed frequency; and

with the current circuit via the semiconductor switch element as a first current circuit to the starting motor, an auxiliary current circuit to the starting motor adapted to be in parallel to the first current circuit and to open and close independently of the first current circuit.

2. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued in an automatic stop period of the engine after an automatic stop request is issued during driving of the engine, the auxiliary current circuit is closed.
3. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued after an automatic stop request is issued during driving of the engine and the engine is completely stopped, the auxiliary current circuit is closed.
4. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued after an automatic stop request is issued during driving of the engine and the engine starts automatic stop, the auxiliary current circuit is closed.
5. The engine starting system according to claim 1, wherein, when vehicle self-propulsion in the starting motor is necessary in a manual transmission car, a

current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM or the Duty signal with the unfixed frequency, and the auxiliary current circuit is used as a main current path to the starting motor.

6. The engine starting system according to claim 1, wherein, in the first current circuit to the starting motor via the semiconductor switch element, when a temperature of the semiconductor switch element rises beyond an acceptable range or becomes dysfunctional, energization to the starting motor is performed only by the second current path.

7. The engine starting system according to claim 1, wherein, in the case where some time is taken until the control means for controlling the semiconductor switch element becomes operative, for example, in the case of engine start by Key, a current can be supplied to the starting motor using only the auxiliary current circuit.

8. The engine starting system according to claim 1, wherein, in the case of starting when an engine is cold, a current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM or the Duty signal with the unfixed frequency, and the auxiliary current circuit is used as a main current path to the starting motor.

9. The engine starting system according to claim 1, wherein means for opening and closing the auxiliary current circuit is performed by the same or similar semiconductor switch element as or to the semiconductor switch element formed in the first current circuit.

10. The engine starting system according to claim 1, wherein the first current circuit and the auxiliary current circuit are controlled so that respective functions may be alternate or at nearly equal use frequencies.

11. The engine starting system according to claim 9, wherein the first current circuit and the auxiliary current circuit are controlled so that respective functions may be alternate or at nearly equal use frequencies.

12. A control method of an engine starting system including:

a starting motor;
a first current circuit having a semiconductor switch element provided in a middle and opening and closing in response to operation of the semiconductor switch element;
control means for restricting a current by con-

trolling the semiconductor switch element using a Duty signal by PWM or a Duty signal with an unfixed frequency; and
 a second current circuit having a mechanical switch provided in a middle and opening and closing in response to operation of the mechanical switch,
 a current being supplied to the starting motor via the first current circuit and/or the second current circuit to start an engine of a vehicle,
 the method comprising
 first opening either of the first current circuit or the second current circuit according to a state of the semiconductor switch element and/or the engine after the first current circuit and the second current circuit are closed.

13. The control method of the engine starting system according to claim 12, wherein, when the engine negatively rotates, and then, the engine positively rotates, the second current circuit is first opened.
14. The control method of the engine starting system according to claim 12, wherein, when the engine positively rotates after a restart request of the engine is issued in a period for stopping the engine on an automatic stop request during driving of the engine, the second current circuit is first opened.
15. The control method of the engine starting system according to claim 12, wherein, when the semiconductor switch element is in a state that the temperature is a predetermined value or higher or current x energization time is a predetermined value or higher, the first current circuit is first opened.

Amended claims in accordance with Rule 137(2) EPC.

1. An engine starting system including a semiconductor switch element and a starting motor, and starting an engine of a vehicle by drive power of the starting motor by turning on a current circuit to the starting motor according to an instruction signal using the semiconductor switch element, the system comprising:

restricting means for restricting energization to the starting motor by controlling the semiconductor switch element using a Duty signal by PWM or a Duty signal with an unfixed frequency; and
 with the current circuit via the semiconductor switch element as a first current circuit to the starting motor, an auxiliary current circuit to the starting motor adapted to be in parallel to the first current circuit and to open and close inde-

pendently of the first current circuit.

2. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued in an automatic stop period of the engine after an automatic stop request is issued during driving of the engine, the auxiliary current circuit is closed.
3. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued after an automatic stop request is issued during driving of the engine and the engine is completely stopped, the auxiliary current circuit is closed.
4. The engine starting system according to claim 1, wherein, at restart when a restart request of an engine is issued after an automatic stop request is issued during driving of the engine and the engine starts automatic stop, the auxiliary current circuit is closed.
5. The engine starting system according to claim 1, wherein, when vehicle self-propulsion in the starting motor is necessary in a manual transmission car, a current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM or the Duty signal with the unfixed frequency, and the auxiliary current circuit is used as a main current path to the starting motor.
6. Amended) The engine starting system according to claim 1, wherein, in the first current circuit to the starting motor via the semiconductor switch element, when a temperature of the semiconductor switch element rises beyond an acceptable range or becomes dysfunctional, energization to the starting motor is performed only by the auxiliary current circuit.
7. The engine starting system according to claim 1, wherein, in the case where some time is taken until the control means for controlling the semiconductor switch element becomes operative, for example, in the case of engine start by Key, a current can be supplied to the starting motor using only the auxiliary current circuit.
8. The engine starting system according to claim 1, wherein, in the case of starting when an engine is cold, a current is restricted by opening the first current circuit or controlling the semiconductor switch element using the Duty signal by PWM or the Duty signal with the unfixed frequency, and the auxiliary current circuit is used as a main current path to the starting motor.

9. The engine starting system according to claim 1, wherein means for opening and closing the auxiliary current circuit is performed by the same or similar semiconductor switch element as or to the semiconductor switch element formed in the first current circuit. 5

10. The engine starting system according to claim 1, wherein the first current circuit and the auxiliary current circuit are controlled so that respective functions may be alternate or at nearly equal use frequencies. 10

11. The engine starting system according to claim 9, wherein the first current circuit and the auxiliary current circuit are controlled so that respective functions may be alternate or at nearly equal use frequencies. 15

12. A control method of an engine starting system including: 20

a starting motor;
 a first current circuit having a semiconductor switch element provided in a middle and opening and closing in response to operation of the semiconductor switch element; 25
 control means for restricting a current by controlling the semiconductor switch element using a Duty signal by PWM or a Duty signal with an unfixed frequency; and 30
 a second current circuit having a mechanical switch provided in a middle and opening and closing in response to operation of the mechanical switch, 35
 a current being supplied to the starting motor via the first current circuit and/or the second current circuit to start an engine of a vehicle, the method comprising
 first opening either of the first current circuit or the second current circuit according to a state of the semiconductor switch element and/or the engine after the first current circuit and the second current circuit are closed. 40

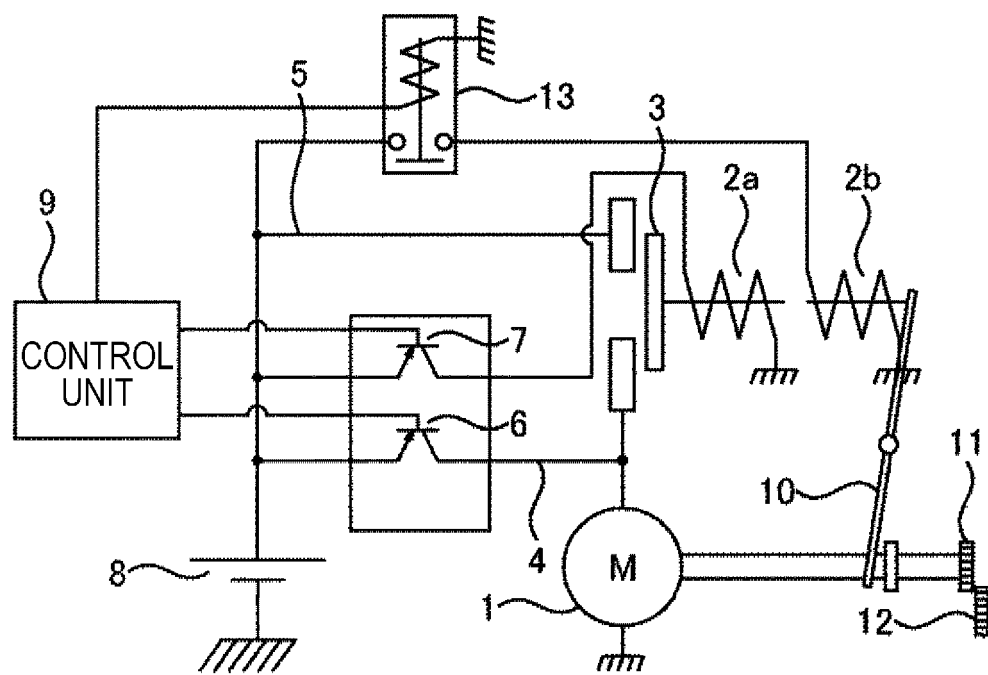
13. The control method of the engine starting system according to claim 12, wherein, when the engine negatively rotates, and then, the engine positively rotates, the second current circuit is first opened. 45

14. The control method of the engine starting system according to claim 12, wherein, when the engine positively rotates after a restart request of the engine is issued in a period for stopping the engine on an automatic stop request during driving of the engine, the second current circuit is first opened. 50

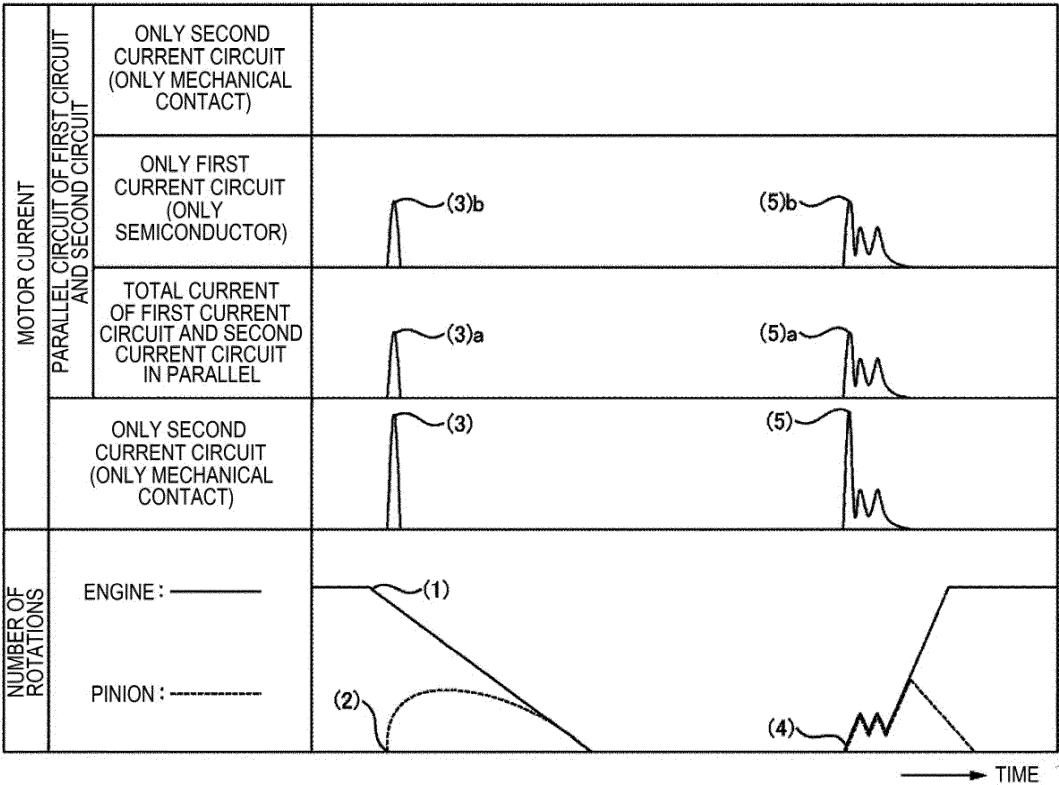
15. The control method of the engine starting system

according to claim 12, wherein, when the semiconductor switch element is in a state that the temperature is a predetermined value or higher or current x energization time is a predetermined value or higher, the first current circuit is first opened.

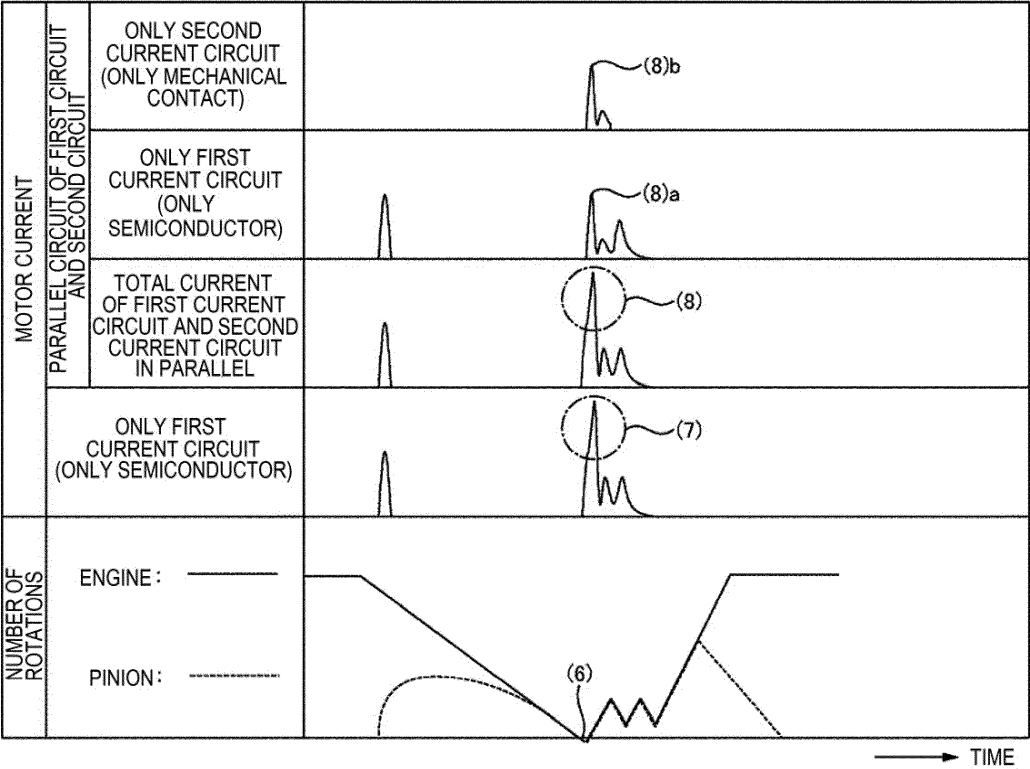
[FIG. 1]



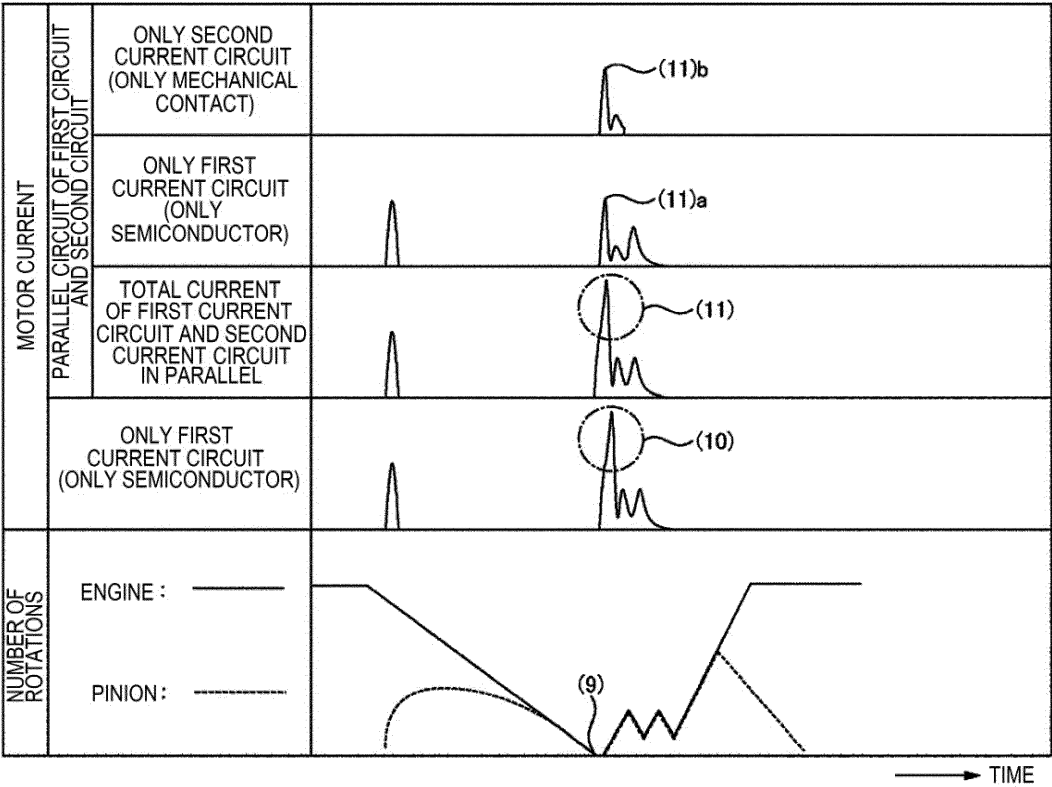
[FIG. 2]



[FIG. 3]



[FIG. 4]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/060504

A. CLASSIFICATION OF SUBJECT MATTER

F02N11/08(2006.01)i, F02D29/02(2006.01)i, F02N15/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02N11/08, F02D29/02, F02N15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-360478 A (Mitsubishi Electric Corp.), 24 December 2004 (24.12.2004), paragraphs [0028] to [0040]; fig. 1 (Family: none)	1-15
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 54179/1991 (Laid-open No. 7962/1993) (Hitachi, Ltd.), 02 February 1993 (02.02.1993), page 4, line 23 to page 3, line 17; fig. 1 to 2 (Family: none)	1-15

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
26 May, 2011 (26.05.11)Date of mailing of the international search report
07 June, 2011 (07.06.11)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/060504

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2004-156589 A (Denso Corp.), 03 June 2004 (03.06.2004), paragraph [0051]; fig. 4 & DE 10347683 A	15

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2616510 B [0006]
- JP 4214401 B [0006]